

THE BUXACEAE IN THE SOUTHEASTERN
UNITED STATES¹R. B. CHANNELL² AND C. E. WOOD, JR.³

BUXACEAE Dumortier, Comment. Bot. 54. 1822, nom. cons.

(BOXWOOD FAMILY)

Monoecious [or dioecious, rarely perfect-flowered] evergreen shrubs, subshrubs, or rhizomatous herbs [rarely trees], with entire or dentate, alternate or opposite, exstipulate leaves, the hypogynous flowers actinomorphic, borne in usually dense racemes, spikes, or heads, the staminate above the carpellate, the latter rarely solitary, both usually subtended by 1 to several bracts and bracteoles. Perianth of 4 [or 6] imbricate tepals in 2 pairs [or in whorls]. Androecium of 4 [or 6] stamens opposite the tepals, sometimes surrounding a central nectary [or a rudimentary gynoecium], the distinct filaments often thickened and bearing large anthers. Gynoecium [2- or] 3-carpellate with [as many or] twice as many locules, each with [2 or] 1 (respectively) pendulous anatropous ovules, the carpels connate below, distinct above, grading at length into linear-subulate style branches stigmatic along the inner surface, often becoming divergent, divaricate or recurved in fruit. Fruit [a loculicidal capsule forcibly ejecting the seeds (*Buxus*) or] apparently indehiscent but capsular, baccate [or drupaceous], regularly failing to dehisce, disarticulating below, falling entire and freeing the enclosed seeds from the base or by degeneration of fruit pulp. Seeds dark brown or black, shining, sometimes conspicuously carunculate; endosperm fleshy. (Buxacées Loiseleur, Man. Pl. Us. Indig. 2: 495. 1819, nom. inval.) TYPE GENUS: *Buxus* L.

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This treatment was originally prepared by Channell. Channell's student, H. C. Robbins, later studied the genus *Pachysandra* under his supervision and produced the thesis quoted in the references. Channell and Wood have updated the text and references. The illustration of *Pachysandra procumbens* was prepared by Dorothy H. Marsh, with Channell's dissections and supervision, from plants grown at the Arnold Arboretum and fruits collected by Elsie Quarterman in Tennessee in May, 1957 (GH). We are indebted to Barbara Nimblett for her help with the references and the manuscript.

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An apparently ancient group, to judge from the diversity of the constituents (including about 70 species of *Buxus*, seven or eight of *Notobuxus* Oliver, 11 of *Sarcococca* Lindley, and four of *Pachysandra* Michaux) and the widespread intercontinental distribution, especially in the Old World tropics. The family has been treated as a tribe of the Euphorbiaceae (Bentham; Bentham & Hooker), or a "series" (Buxae) of the Celastraceae (Baillon, 1875), or assigned variously to the Celastrales (Scholz), the Euphorbiales (Takhtajan, 1959, 1969; Cronquist, 1968, 1981), the Hamamelidales (Takhtajan, 1954, 1980; Hutchinson, 1969, 1973), the Pittosporales (Thorne, 1976, 1983), and a separate order Buxales in Dahlgren's (1983) Rosiflorae. Airy Shaw (in Willis) thought the Buxaceae to be related to the Euphorbiaceae and perhaps the Celastraceae.

The pollen of *Pachysandra* and *Sarcococca* is similar. The spheroidal grains are radially symmetrical. In *Pachysandra* they are polyforate, with more than 12 apertures or foramina. They have a pattern characteristic of *Croton* L. and other Euphorbiaceae, with well-defined, regularly arranged triangular excrescences of the sexine that form reticulate polygons. The pollen of *Sarcococca Conzattii* (Standley) I. M. Johnston (*S. guatemalensis* I. M. Johnston) is quite different from that of the Asiatic species and that of *Pachysandra* (see Gray & Sohma), strengthening Sealy's (1986) exclusion of this species from *Sarcococca*.

The pollen of *Buxus* evidently in no way resembles that of either *Pachysandra* or *Sarcococca*, being similar, however, to that of *Styloceras* Juss. (Stylocerataceae), a genus comprising four species of glabrous trees of western tropical South America and related to Buxaceae but differing, according to Airy Shaw (in Willis), in the naked staminate flowers with many more or less sessile anthers borne on a solitary bract, and in the locules of the ovary that are completely divided by secondary longitudinal septa (but cf. *Pachysandra procumbens*). The staminate flowers of *Styloceras* appear to be simple androphyls, as in *Didymeles*, a genus of two arborescent Madagascan endemics and the basis for the Didymeleaceae, the fruits of which are large, one-seeded drupes (cf. the berries of *P. terminalis*), the flowers evidently primitively simple, and the genus possibly having some relationship to the Buxaceae through the Stylocerataceae.

It is of interest in passing that the distribution of the Buxaceae, the Stylocerataceae, and the Didymeleaceae together includes the major continental land masses of the world, suggesting that comparative knowledge of the alliances may contribute to a refined appreciation of phytogeography and a better understanding of the efficacy of isolation in phylogeny.

The family is notable for the alkaloids that occur in its members. Gibbs noted, "steroid alkaloids in bewildering numbers occur in: *Buxus*, *Pachysandra*, *Sarcococca*" (p. 1217) and "the *steroid alkaloids* of the Buxaceae certainly define that family" (p. 1221).

The Buxaceae are economically important for various ornamentals used in horticulture, principally *Buxus* (various species, especially *B. sempervirens* L. and *B. microphylla* Sieb. & Zucc., selections, and cultivars, including those variously known as English, Japanese, Korean, Chinese, and 'California' box or boxwood), and to a lesser extent representatives of four or five (see Bailey *et al.* and Sealy, 1949) species of *Sarcococca* (including *S. ruscifolia* Stapf, sweet box, and *S. saligna* (D. Don) (Müll.-Arg., willow-leaf box) and *Pachysandra*

terminalis Sieb. & Zucc., Japanese spurge or Japanese pachysandra, widely used as a ground cover. The firm, close-grained wood of certain members of *Buxus* (especially *B. sempervirens*) is used for turning and engraving. Other products also find use in commerce.

A useful liquid wax, difficult to synthesize commercially, is obtained from the seeds of *Simmondsia chinensis* (Link) Schneider (*S. californica* Nutt.), the jojoba or goatnut. Contrary to the connotation of the original epithet, this long-lived, low shrub (under cultivation attaining a height of three feet when staked) is indigenous to large areas of the Sonoran Desert of California, Arizona, and northern Mexico. Although long assigned to the Buxaceae (Müller; Pax, 1890; Hutchinson, 1967; Scholz), it constitutes a separate family taxonomically, the Simmondsiaceae.⁴ The seeds contain up to 25 percent liquid, unsaturated wax, which can be solidified by hydrogenation, used in the manufacture of extreme-high-pressure lubricants, especially for transmissions in heavy-duty vehicles. It is a suitable substitute in uses calling for spermaceti (sperm-whale "oil," itself technically a wax), carnauba wax, and beeswax, and it is currently also used in a number of cosmetics. Resistant to pests and diseases, jojoba thrives without irrigation in areas where rainfall is less than 24 cm annually, with mature plants producing up to 12 pounds dry weight of seeds during the period. It has elicited considerable interest as a potential agricultural crop, not only in desert regions of the North American Southwest, but in arid regions of Argentina, Chile, Israel, Africa, and Australia.

The monogeneric Simmondsiaceae have flowers with (4) 5 (6) tepals, numerous (8–12) stamens, unique pollen, and a solitary ovule in each of the three locules (cf. *Pachysandra*); usually a single large seed with a large embryo and little or no endosperm; and anomalous wood structure with several concentric rings of vascular strands, besides other distinctive anatomical features. In pollen and anatomy *Simmondsia* has much in common with some members of the Centrospermae, although an actual relationship with them is difficult to envision, according to Airy Shaw (in Willis), who suggested that the most probable affinity of *Simmondsia* is with the Monimiaceae (*sensu stricto*), from which it differs in the syncarpous gynoecium and fruit and the scanty or absent endosperm. However, Wettstein (1924, 1935), Takhtajan (1969), Cronquist (1981), Thorne (1983), and Dahlgren all have associated *Simmondsia* with the Euphorbiales. Scogin (see references to Simmondsiaceae) found that in taxa from a wide array of families examined for cross-reactivity with *Simmondsia* anti-serum, a reaction was detected only with three species of Euphorbiaceae. It

⁴The name Simmondsiaceae is usually attributed to Van Tieghem (Ann. Sci. Nat. VIII. 5: 289–338. 1897, the section on *Simmondsia* repeated almost verbatim in Jour. Bot. Morot 12: 103–112. 1898), but nowhere did he use the Latin form. He always referred to the family as "Simmondsiacées." (And in none of his papers do we find anything but the French vernacular form for family names, and frequently for generic ones, e.g., "le genre Simmondsie.") Not being in Latin, these names are invalidly published. Insofar as we have been able to determine, the name Simmondsiaceae should be cited as Takhtajan ex Dostál, Botanická Nomenklatura, 217. 1957. Airy Shaw's citation (in Willis) attributing the name to (Pax) Van Tieghem is certainly incorrect, for nowhere did Van Tieghem either use the correct form of the family name or mention Pax.

seems clear that the relationships of *Simmondsia*, whatever they may be, are not with the Buxaceae as formerly thought.

Because of the economic interest of *Simmondsia*, a selected series of references to this genus is included here following those for the Buxaceae.

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REFERENCES TO *SIMMONDSIA* AND SIMMONDSIACEAE:

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1. **Pachysandra** Michaux, Fl. Bor.-Am. **2**: 177, 178. *pl.* 45. 1803.

Evergreen or semi-evergreen, erect, decumbent, or prostrate, sympodial [shrubs, subshrubs, or] perennial herbs, usually with [woody or] fleshy rhizomes, fibrous roots, and simple, alternate, exstipulate, petiolate leaves with glabrous, glabrescent, or pubescent, variously toothed, subdentate to nearly entire blades with prominently 3-nerved pinnate venation. Inflorescences spicate, basal [or axillary or terminal], the distal portions occupied by 5–40 pedicellate, subsessile, or sessile carpellate flowers. Staminate flowers subtended by a single ciliate-pubescent bract, and with a perianth of 4 decussate, imbricate, ciliate tepals sometimes with accompanying bracteoles, and (2 or) 4 (or 6) distinct stamens with long-exserted, thickened or compressed clavate filaments, each surmounted by a linear-oblong, rotund to sagittate, dorsifixed, longitudinally dehiscent, introrse anther, the connective sometimes prolonged as an appendage; pollen spheroidal, polyforate, with polygonal ornamentation. Carpellate flowers inserted on the inflorescence axis below the staminate flowers, subtended by 7–13 distinct imbricate herbaceous bracts, with 4 or more acute tepals; ovary [2- or] 3-carpellate, the carpels connate below, each with 2 locules separated by a false partition, each locule then containing a single pendent ovule; the styles [2 or] 3, subulate to linear, erect or spreading at anthesis, becoming recurved in fruit; stigma linear or linear-lanceolate, papillose, usually sulcate, covering the inner surface of the style branches. Fruit capsular [or baccate], indehiscent but becoming detached basally and falling entire. Seeds trigonal, with [or sometimes without] a micropylar caruncle, the smooth, glossy testa finally hard and dry, dark brown or black, the endosperm whitish and oily, the embryo straight, the cotyledons considerably broader than the radicle. TYPE SPECIES: *P. procumbens* Michaux. (Name from Greek *pachys*, thick, and *andros*, of a man, alluding to the thick filaments of the stamens.)

The genus includes four species: *Pachysandra procumbens*, Allegheny spurge or Allegheny-Mountain spurge, indigenous to the southeastern United States, and three indigenous to eastern Asia. *Pachysandra terminalis* Sieb. & Zucc. (China and Japan) and *P. axillaris* Franchet (Yunnan, China), as their epithets connote, are well marked and, together with *P. procumbens*, easily distinguished by the disposition of the inflorescences; *P. stylosa* Dunn (China) is characterized by its long, prominent styles, recurved in fruit. Treated by Robbins (1962) on the basis of herbarium material as comprising six taxonomic varieties, the last species deserves reexamination on the basis of more and better material. Cheng has recently (1980) treated *P. stylosa* as a variety of *P. axillaris*.

The geographic distribution of the genus, with a single species endemic to the eastern United States disjunct from the four of eastern Asia, exemplifies the well-known affinities of the floras of the two regions pointed out by Asa Gray in 1840 and elaborated by him in 1846. Fossil evidence of the occurrence of *Pachysandra* in the western United States might be thought to lend credence to the belief that the genus was a member of the northern temperate "Arcto-Tertiary" flora, but Leopold & Macgintie pointed out that *Pachysandra* "appears to have had ancestral types at middle latitudes in America well before the 'Arcto-Tertiary' flora came into being." They further suggested that the "Pachysandra-Sarcococca group may well have had a New World origin." The center of morphological and taxonomic diversity, however, is clearly in eastern Asia.

Gray & Sohma have shown that *Sarcococca* and *Pachysandra* have distinctive and related pollen structure. Although the pollen morphology of the two genera merges when they are viewed as a whole, some types are distinctive—for example, the pollen of *P. procumbens* has a sculpture pattern and a pore frequency that set it off from that of other species of *Pachysandra* and *Sarcococca*. Muller noted that *Pachysandra*-type pollen is known from the Campanian of Canada and from the Campanian-Danian interval of Germany. Later Cretaceous records of the group come from deposits of Maestrichtian age in Wyoming (Leopold & Macgintie), California, Montana, and Canada (see Muller). In the eastern United States pollen of the *P. procumbens* type is known from the middle Eocene and from the Miocene (Leopold & Macgintie). "Most of the available western records of the group appear to be related to Old World species."

Believed to have survived the geologic changes of the past few million years in the limestone plateau country of central Kentucky, Tennessee, and adjoining states, *Pachysandra procumbens* is now of local occurrence, for the most part in rich woods of moist ravines near streams.

Braun considered *Pachysandra procumbens* to be a characteristic herbaceous plant of the Western Mesophytic Forest Region, an area having as its eastern boundary the western escarpment of the Cumberland and Allegheny plateaus and as its western boundary the loess bluffs of the Mississippi River. She remarked that, although commonly thought to be rare, it is an abundant plant of mesophytic woods in the region.

Pachysandra procumbens is of some floristic, phytogeographical, and wild-flower interest. A strongly rhizomatous herb of rich woods, it displays sympodial growth, the shoots bearing approximate, mottled, strongly dentate, pubescent leaves, urticaceous in superficial appearance, and abscising as simultaneously replaced by new growth from scaly basal buds in spring. (As might be expected, anomalous flowers with two or four styles instead of three, and five stamens instead of four, have been described.) Old reports of the occurrence of the plant in West Virginia and New Jersey, as well as at Memphis, Tennessee, are probably erroneous but are of considerable interest if verified. The species has been reported from central Kentucky, central and eastern Tennessee, western North Carolina, western Georgia, Alabama, Mississippi, the Marianna Caverns in Jackson County, Florida, and the Tunica Hills of

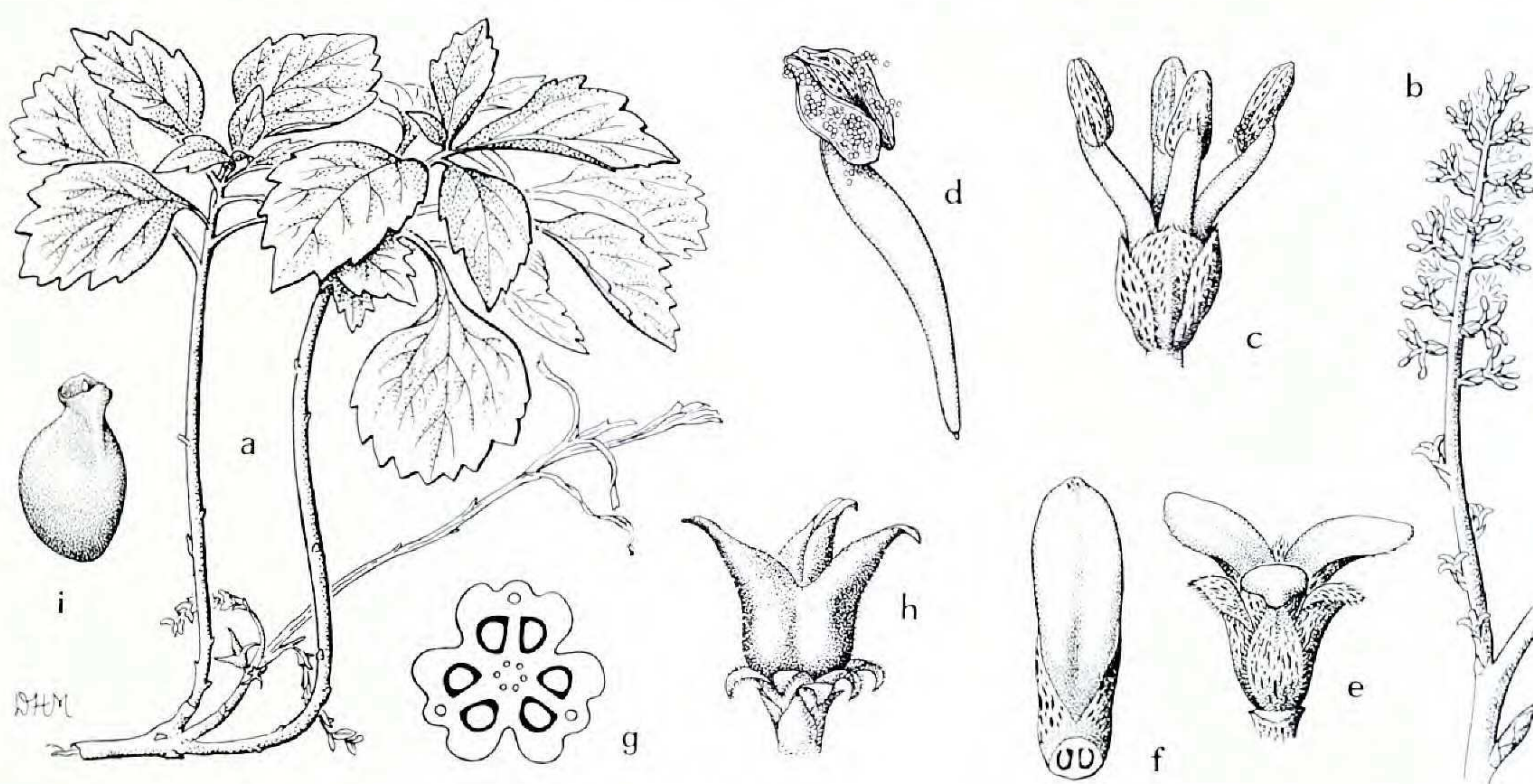


FIGURE 1. **Pachysandra**. a–h, *P. procumbens*: a, portion of plant with fruit, $\times \frac{1}{4}$; b, inflorescence, carpellate flowers below the staminate, $\times \frac{1}{2}$; c, staminate flower, $\times 2$; d, stamen, $\times 4$; e, carpellate flower, $\times 2$; f, carpel, the lower portion in longitudinal section to show the single ovule suspended in each of the 2 locules, $\times 4$; g, semidiagrammatic cross section of young ovary to show 6 locules, each with a single ovule, $\times 6$; h, mature fruit, $\times 1$; i, seed, $\times 3$.

Louisiana. Its distribution outlines the dissected portion of the Highland Rim Province surrounding the Central Basin of Tennessee, but it is not known to occur on outlying portions of the Rim isolated within the Basin.

Robbins (1962) has reported results of investigations of embryology and life history in *Pachysandra procumbens*. Microspore mother cells undergo the first meiotic division, giving rise to two dyad nuclei without cytokinesis. The second division, followed by simultaneous furrowing, results in a tetrahedral arrangement of the pollen tetrad. Excrescences of the sexine, arranged as reticulate polygons, develop after the microspores are released from the mother-cell wall. (See J. Gray and J. Gray & Sohma for illustrations of pollen.)

The ovary is divided into six locules by three true and three false partitions. Early in development the ovary is three-locular, each locule enclosing two ovules. Later it becomes six-locular by formation between the ovules of secondary partitions that are thinner than the original septa (see FIGURE 1). Differentiation of the ovules and the appearance of the archesporial cells occur in late June of the year prior to anthesis, which happens as early as February of the following year.

The anatropous ovule has two integuments. The archesporial cell, differentiating from a hypodermal cell of the nucellus, divides, forming a primary parietal cell and a primary sporogenous cell, the latter, pushed into the nucellus, functioning as the megaspore mother cell. The primary sporogenous cell is separated from the nucellar epidermis by several layers of cells, a characteristic of crassinucellate ovules.

Megagametophyte (embryo sac) development follows the *Polygonum* or normal course, being of the monosporic, eight-nucleate type. Pollen tubes make

their way between the stigmatic papillae down through the tissues lining the stylar canal, passing between the cells rather than penetrating them. Before fertilization a protuberance (obturator) develops by proliferation of placental cells immediately dorsal to the ovule. Growing downward, it meets the outer integument, which has grown over and enclosed the ovule, and continues to develop until it forms a hood over the nucellus, possibly functioning in the penetration of the pollen tube into the ovule. Proliferation of the outer integument in the micropylar region results in the formation of a prominent caruncle, a conspicuous feature of the mature seed. All of the nucellar tissue, except the epidermis and groups of cells at the chalazal and micropylar ends of the seed, disappears with development of the cellular-type endosperm, which constitutes the bulk of the seed.

The trigonal, black, shining, carunculate seeds are shed in July and August, remain dormant through the following fall and winter, and germinate in late March and early April in close proximity to the parent plants, beneath leaf litter, usually in direct contact with moist mineral soil. Rupture of the seed coat occurs as the rapidly growing primary root emerges through the caruncle. Eventually the seed coat is shed, the cotyledons and epicotyl still enclosed within the surrounding fleshy endosperm. The cotyledons and epicotyl eventually emerge, with only remnants of the endosperm then being evident.

The cotyledons, which persist for as long as a year, have thick, glossy, green blades and short petioles, the latter undergoing elongation as development proceeds. Within six weeks of germination, the minute epicotyl develops into a short aerial stem bearing three to five small foliage leaves. Growth is slow, the shoot attaining a height of only five inches by the end of the first year. Secondary aerial shoots develop from the base of the initial shoot at the point of attachment of the cotyledons. The rapid growth of these shoots results in the establishment of lateral branches that soon overtop the primary axis. Protuberances that develop along with the lateral aerial branches are evidently the source of the rhizomes and adventitious roots. Eventually the seedling develops a sympodially branched rhizome system. The flowering of seedlings was not observed, although their development was followed for three years.

Established clones of *Pachysandra procumbens* have a well-developed sympodial system of rhizomes terminated by decumbent aerial shoots surmounted by a cluster of approximate leaves, diminishing in size distally and mottled pale green (if not silver) on dark green in late fall and winter. Upon excavation clones with as many as 38 aerial shoots were found to be interconnected by underground rhizomes. Each aerial shoot dies as the result of abscission, which occurs in spring as a new vegetative bud gives rise to a replacement shoot. A lateral vegetative bud, already established at the base of the old shoot stub, now rapidly develops into a new aerial shoot. This process, repeated successively year after year, results in the prominent and characteristic sympodium, one actual analysis of which estimated the age at 34 years! "Dichotomous" branching of the axis occurs when two lateral buds of a single segment develop into leafy shoots. Indeed, the typical circular growth habit of well-established clones of considerable age is attributable to the repetition of such branching.

It seems plausible, therefore, that an entire "population" may in fact represent a single clone, having developed from one plant by repeated sympodial growth and dichotomous branching, followed by subsequent fragmentation or degeneration of older portions of the rhizome system.

By early May or June of the year prior to the spring in which a given aerial shoot abscises, not only is a lateral shoot bud developed but so also are one to three flower buds. These occupy a lateral position, well below the point of shoot abscission. Anthesis occurs as early as mid-February in the vicinity of Nashville, Tennessee, but usually during the last week of March and early April. Either the staminate or the carpellate flowers may open first. In some instances the staminate flowers will have fallen before the carpellate ones open. There appears to be no single, regular, progressive order of events with respect to the details of flowering—probably the differential effect of short-term environmental influences upon the preformed flower parts. The conspicuous white staminal filaments elongate rapidly, well overtopping the sepals. The originally erect style branches diverge, curve outward, and expose the inner stigmatic surface, which is covered with minute papillae.

The whitish pollen grains are exposed by longitudinal splitting and slight recurving of the anther walls. A heavy "rain" of pollen onto the carpellate flowers below commonly occurs, with a glistening appearance of the stigmatic surface presumably indicating receptivity. Soon after anthesis the anthers fall, carrying with them adherent pollen and thus possibly providing a second opportunity for pollination.

During anthesis the staminate flowers emit a rather penetrating odor faintly resembling that of carnations or, to some people, the essence of ammonia or of an amine. It has been described as being pleasantly fragrant at the outset, later becoming sharp and penetrating. Insects, including beetles and bees, have been reported to visit the staminate flowers but never the carpellate ones. Red spiders (mites) covered with pollen have been observed on and in both types of flowers. There is no question but that the staminate flowers are structurally equipped to attract insects and are effective in doing so. In addition to the attractant features of the conspicuous white filaments and the abundant whitish pollen, the existence of a central nectary in the staminate flowers would appear to be especially significant. Evidence that self-pollination occurs is unquestionable. That insects provide a medium for cross-pollination seems not only possible but probable.

The plant is hardy well to the north of its native range and is sometimes grown as an ornamental novelty in partial shade, where it spreads slowly. Isolated clones in cultivation—indeed, those in nature—behave as though they may be genetically self-sterile, apparently never setting seeds. That fruits are seldom seen in nature is believed to reflect actual absence, as opposed to faulty, casual, or cursory observation.

In the self-pollination experiments of Robbins (1962), 50 plants, collected from five different populations, were used. These bore a total of 288 carpellate flowers, representing a potential of 1368 seeds (on the basis of six seeds per fruit). Of the 228 flowers self pollinated, only 104 set fruit, with a potential of

624 seeds. However, only 17 seeds were actually produced, and these by only three plants. Ten fruits contained only one seed each, two contained two seeds each, and only one contained three.

The crossing experiments made use of 43 plants with a total of 191 carpellate flowers, representing a potential of 191 fruits and 1146 seeds. Only 57 (30 percent) of the flowers set fruit, and only six of these produced seeds, the total number of seeds being 12.

Of the 423 carpellate flowers on 40 plants used in the initial apomixis test in which pollen was withheld, 87 (21 percent) set fruit, but none produced seeds. In a "replication" of the experiment the following spring, 98 carpellate flowers on 28 plants were observed. None of these produced fruits. In a third replication 95 carpellate flowers on 13 plants were observed, but again no fruits were set. In all experiments 248 fruits out of a potential of 1991 were produced. The total number of seeds produced was only 29, these being recovered from only nine fruits.

The experiments indicate that the species is both self- and cross-compatible. The possibility of apomixis being involved, although unlikely, cannot be ruled out entirely on the basis of the negative results obtained. The general paucity of fruits in nature tends to mitigate against apomixis, however. Pollination could be shown to be a stimulus to apomictic development, for in most pseudogamous species the embryo begins development autonomously, but the endosperm will not develop unless it is fertilized.

The overall results of these experiments further emphasize previous observations that development of fruits in *Pachysandra procumbens* is sporadic and that seed production is generally rare. This implies that the species may indeed have a very low degree of sexual fertility. Vegetative propagation has assumed a major role, with reproduction involving seeds occurring only rarely. As previously pointed out, the possibility exists that an entire population occupying the slopes of a ravine could represent a single clone, having originated vegetatively from a single plant.

The combination of rhizomatous habit, morphological constancy, restricted habitat, and low sexual fertility indicates that *Pachysandra procumbens* is a nonaggressive if not "senile" species with a very low evolutionary potential. Like other persistent perennials of low sexual capacity inhabiting ecologically closed communities, *P. procumbens* no doubt benefits from either a sustained low or a sporadic incidence of sexual output. Whether or not genetic self-incompatibility operates between and among clones is not known, although the crossing results suggest the existence of such a possibility.

Of the species of *Pachysandra*, *P. terminalis* is clearly the most important economically, being widely used in horticulture as an ornamental ground cover since its introduction into the United States in the 1800's. It is known in the trade by the somewhat contrived name Japanese spurge. Its glossy evergreen leaves, low, creeping growth habit, and tolerance of shade make it an attractive subject for ground-cover use. It is propagated vegetatively. It is unique in having terminal inflorescences and two-carpellate, white, baccate fruits (cf. *Didymeles*), described as about the size of a 'Delaware' grape, the pulp decidedly sweet. Other distinctive characters include the elevated veins of the adaxial surface

of the leaf blades, the comparatively small stigmatic area occupying only the distal one-third of the style branches, the presence of a coriaceous bract and two bracteoles subtending each staminate flower, and the somewhat elongated pedicel of the carpellate flowers.

Although *Pachysandra terminalis* in cultivation is subject to attack by various insect pests and fungus diseases, it is in general resistant to them. Dodge (1944a) reported that canker blight or leaf-spot disease of the plant is due to the fungus *Volutella pachysandricola*. He also noted susceptibility to fungi of the genera *Phylosticta* and *Glocosporium* and to attack by the scale insect *Chionaspis evonymi*.

While the leaves of Chinese plants of *Pachysandra terminalis* are reportedly somewhat smaller than those of the Japanese ones, no taxonomic significance has yet been attached to the difference. Variegated selections with ivory-white areas confined to the leaf margins have been described and are extant in the horticultural trade.

Pachysandra stylosa Dunn var. *glaberrima* Hand.-Mazz. also finds limited use in ornamental horticulture, mainly as a ground-cover subject, being similar in gross aspect to the preceding.

Horticultural use of *Pachysandra axillaris* and the varieties of *P. stylosa* is rarely, if ever, encountered, although individuals of these species are occasionally grown for exhibition in botanical gardens. These plants for the most part present a more nearly woody, even shrubby habit of growth and have thicker, more coriaceous leaves than do the other two. It would appear that they deserve greater attention horticulturally.

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